

# CHEMICAL AND MINERALOGICAL CHARACTERIZATION OF LATERITIC IRON ORE DEPOSIT AT AUCHI, EDO STATE, NIGERIA

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## ABSTRACT

The laterite iron ore deposit at Auchi, Edo State, Nigeria was studied chemically and mineralogically. The results of the chemical assay are moisture (0.02 - 1.11%), L. O. I. (2.31 - 2.93%),  $\text{Fe}_2\text{O}_3$  (50.40 - 66.29%),  $\text{Al}_2\text{O}_3$  (17.25 - 25.50%), CaO (0.32 - 0.36%), MgO (2.60 - 2.96%) and  $\text{SiO}_2$  (5.22 - 26.00%). The mineralogical studies showed the presence of goethite, diasporite, rutile and kaolinite respectively.

**KEY WORDS:** laterite, goethite, diasporite, rutile and kaolinite.

## INTRODUCTION

Laterites can be defined as clays enriched in ferric and aluminium hydroxides that have a wide spread occurrence in humid tropics as a weathered rocks of all kinds, Read et al (1968). Lateritic soils occur in tropics and sub-tropics where there is high rainfall, intense leaching of the soil and oxidizing warm environment. The accumulation of organic matter is inhibited by the oxidizing conditions and the high rainfall ensures that soluble weathering products are removed (Allen 1995). Laterites vary widely in their composition, depending on their parent rock type, weathering conditions and environment, Schellman (1994). The mineralogical composition of laterite and its use as a possible source of iron and aluminium minerals have been studied, Iwu (1973). The current study of the lateritic iron deposit at Auchi in Edo State is to determine its chemical and mineralogical composition in order to be able to assess the possibility of it being a source of iron and or aluminium minerals.

## MATERIALS AND METHODS

### SAMPLING

The samples were collected on profile basis in each site. The profiles were determined by colour variation, lines of cleavage and depth as described by Onyeobi *et al* (1994). A minimum of fifteen (15) samples were collected per depth in each site. The samples in each profile were obtained by the use of geological hammer and spade and were packaged in polythene bags and transported to the laboratory.

### SAMPLE TREATMENT

The samples were air-dried in the laboratory.

### SAMPLE PREPARATION

The samples collected were kept in the laboratory and allowed to be air-dried. The samples were crushed by use of geological hammer and a laboratory sized jaw crusher. Grinding was carried out by use of two-roll mill and final grinding was carried out

using laboratory mortar and pestle. The finely ground samples were stored in labelled containers.

#### i) Moisture Content

The samples (5g) were weighed in an analytical balance, in 100ml beakers heated at between 105-110°C in a Merment thermostated oven until constant weight were attained. The samples were kept in desiccators, cooled, and weighed again to obtain the weight loss which was calculated as percentage of moisture content. A minimum of three replicate determinations were carried out for each sample.

#### ii. Loss on Ignition (L.O.I)

This represents the total amount of volatile materials present in the samples. In order to determine the loss on ignition, the samples (5g) were weighed in an analytical balance in porcelain crucible, heated at between 400°C for four hours until constant weight were obtained. The samples were thereafter, cooled in the dessicator, weighed and the loss in weight was calculated as percentage of volatile matter present. A minimum of three replicate determinations were carried out for each sample.

#### iii. Atomic Absorption Spectrophotometer Determination

### Chemical Assay

This involved the determination of the chemical make-up of the sample using Atomic Absorption Spectrophotometer. (Bulk Scientific 200A) as described by (Young R.S., 1977).

The determinations were carried out on dry samples which were obtained by taking some quantity of the test sample, heated at 105-110°C for one hour to remove moisture, cooled in a dessicator and thereafter kept in a sealed container. The test sample (1.0g) was weighed into a beaker, sufficient quantity of Aqua-regia ((3:1) HCl:  $\text{HNO}_3$ ) was added into the beaker and the mixture was heated to near dryness. 50%  $\text{H}_2\text{SO}_4$  (10ml) was added and heated until the fumes of  $\text{SO}_2$  were observed. De-ionised water was added and the solution stirred,

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and filtered. The filtrate (A) was kept. The solid residue ( $r_1$ ) was fused with  $\text{Na}_2\text{CO}_3$  at  $1200^\circ\text{C}$  in a muffle furnace. Thereafter,  $\text{HCl}$  (1.5M) was added, warmed and the filtrate (B) was added to the initial filtrate (A). The residue ( $r_2$ ) was kept for silica determination.

The combined filtrate (A + B) was heated to boiling, solid  $\text{NH}_4\text{Cl}$  was added, two drops of methyl red indicator was added and conc. aqueous ammonia solution was added drop wise until all the ammonium hydroxide elements was precipitated ( $P_1$ ) and filtered. The filtrate (C) from the above was kept for alkaline-earth metal determination.

The precipitate ( $P_1$ ) from the above was dissolved in  $\text{HCl}$  (1.5M), warmed and re-precipitated ( $P_2$ ) to remove any occluded alkaline earth metal. The filtrate (D) was added to the previous filtrate (C). The filtrate (D + C) was transferred into a 250ml volumetric flask, and de-ionised water was added to make up to the mark. Aliquot of this was taken for Ca, Mg, Ni, Mn and Cr determinations.

The precipitate from above ( $P_2$ ) was dissolved in warm  $\text{HCl}$  (1.5M), filtered and transferred to a 250ml volumetric flask and de-ionised water was added to make up to the mark (Solution X). Aliquot of solution X was taken for the determination of Fe, Al, Ti, P.V. Replicate preparations were made. For the Atomic Absorption Spectrophotometer determination of aluminum and titanium, nitrous oxide - air flame was used whereas the air-acetylene flame was used for the determination of the other elements. The amount of

each element present was expressed as percentage of the oxide of the metal.

### SILICA DETERMINATION

The total silica was determined using the standard method (ASTM, 1965). The residue from the acid digestion of the samples, was taken into a platinum crucible, moistened with concentrated sulphuric acid and evaporated to dryness. This was taken into a muffle furnace, heated at temperature of  $1200^\circ\text{C}$  for 20 minutes, cooled in a dessicator and weighed. Thereafter 2 drops of  $\text{H}_2\text{SO}_4$  (1:1) was added followed by addition of hydrofluoric acid (10ml), and the content was evaporated to dryness on a hot plate. This was taken back to the muffle furnace and ignited at  $1200^\circ\text{C}$  for 20 minutes, cooled and reweighed. The difference in weight represents the total silica present. Replicate determinations were carried out.

### MINERALOGICAL ANALYSIS

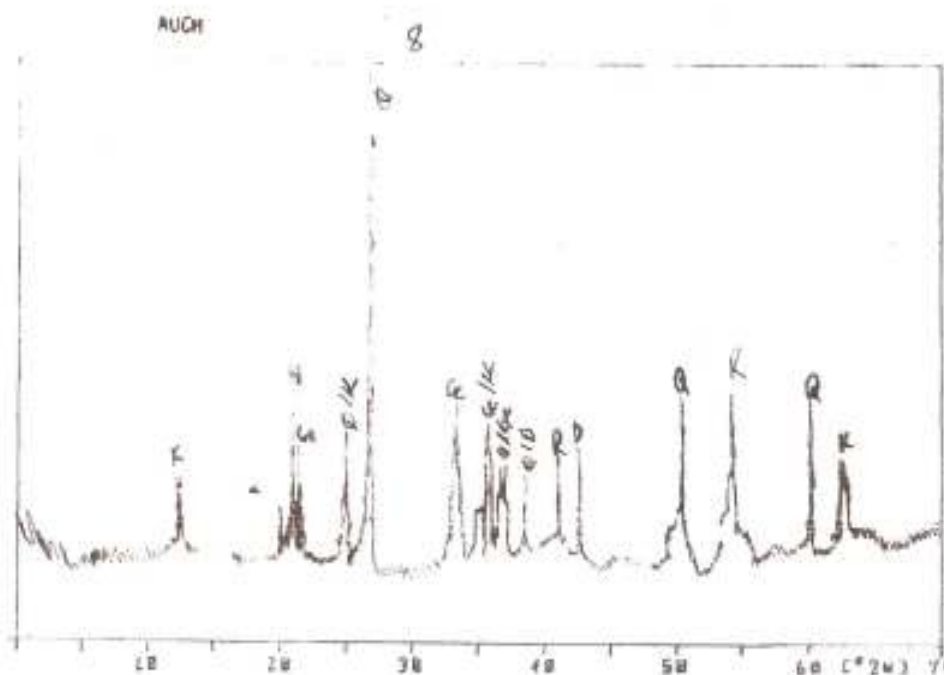
The samples were pulverized to fine particles ( $\leq 2\mu\text{m}$ ) and were subjected to X-ray diffraction using Phillips X-ray Diffractometer PW 1800 with Cu,  $K\alpha$  radiation source. The generator operating conditions were 40KV and 55mA. The Diffractograms obtained were compared with the standard X-ray powder diffraction file published by the Joint Committee on the Power Diffraction Standards (JCPDS) for the identification of the different mineral species.

## RESULTS AND DISCUSSIONS

TABLE 1: RESULT OF THE CHEMICAL ASSAY OF LATERITE IN AUHCI SITE

DEPTH (m)	0-0.5	0.5-1.2	1.2-19	MEAN	STANDARD DEVIATION
Moisture (%)	0.30	1.11	0.02	0.48	0.57
L.O.I (%)	2.31	2.93	2.65	2.63	0.31
$\text{Fe}_2\text{O}_3$ (%)	66.29	58.03	50.40	58.24	7.95
$\text{Al}_2\text{O}_3$ (%)	21.50	25.50	17.25	21.42	4.13
$\text{CaO}$ (%)	0.32	0.35	0.36	0.34	0.02
$\text{MgO}$ (%)	2.61	2.96	2.60	2.72	0.21
$\text{Cr}_2\text{O}_3$ (%)	0.01	0.02	0.06	0.03	0.03
$\text{V}_2\text{O}_5$ (%)	N.D	N.D	N.D	0.00	0.00
$\text{MnO}_2$ (%)	0.01	0.02	0.03	0.02	0.01
$\text{Ni}_2\text{O}$ (%)	0.01	0.03	0.01	0.02	0.01
$\text{P}_2\text{O}_5$ (%)	0.02	N.D	0.01	0.02	0.01
$\text{SiO}_2$ (%)	5.22	8.95	26.00	13.39	11.08
$\text{TiO}_2$ (%)	0.03	0.02	0.01	0.02	0.01
$\text{SiO}_2$	0.14	0.24	0.89	0.42	
$\text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3$					

N.D = Not Detected



**Fig 1: X-Ray Diffractogram of Laterite in Auchi**

K = Kaolinite, Ge = Goethite, R = Rutile, D = Diaspore, Q = Quartz, D = Diaspore

The results of the chemical assay of the lateritic iron deposit at Auchi is as presented in table 1. The values obtained were; moisture content (0.02 – 1.1%), loss on ignition (2.31 – 2.93%) Iron (iii) Oxide (50.40 – 66.24%) aluminum oxide (17.25 – 25.50%) calcium oxide (0.32 – 0.36%) Magnesium Oxide (2.60 – 2.96%) and Silica (5.22 – 26.00%). The oxides of titanium, manganese, nickel, phosphorus, chromium were present in low quantities, vanadium was not detected. The mineralogical study of the lateritic iron deposit (fig 1) revealed the presence of iron mineral as predominantly goethite (FeO.OH), whereas, the aluminum was present as diaspore (AlO.OH) and as a constituent of kaolinite, the silica was present as  $\alpha$ -quartz, rutile (TiO<sub>2</sub>) the titanium mineral was identified.

The results obtained for the moisture content and the loss on ignition (L. O. I.) though low, did not show any marked pattern with depth. The same pattern was observed with the values obtained for magnesium oxide and calcium oxide. However, the values obtained for the oxides of magnesium were significantly higher than those of calcium oxide. The release of these exchangeable cations and their dissolution in water and the higher solubility exhibited by calcium ions is the most probable reason for the values observed. This view is supported by some early workers (Loughnan 1969). The higher values of iron oxide obtained when compared to aluminum oxide on one hand, and the low ratio of silica to iron oxide and aluminum oxide on the other hand positively confirm, that the deposit is lateritic in nature. This view is supported by (Fey et al (1977). However, the progressive increase in the silica values with increasing depth and the positive identification of kaolinite as clay mineral component in the deposit,

indicates the increasing clay content of the deposit with depth. The x-ray diffractogram of the laterites, revealed the presence of goethite (FeO.OH) as the predominant iron mineral, whereas aluminum was present as diaspore (AlO.OH) and as a constituent of kaolinite. The Silica (SiO<sub>2</sub>) was present as a  $\alpha$ -quartz certainly of kaolinite origin. Rutile as titanium mineral was identified. The above mineralogical constituent is indicative of both the degree of weathering and the nature of the rock type which underwent the weathering. This view is supported by Schellmann, (1994).

## CONCLUSION

The laterite studied has high quantity of iron oxide, moderate quantity of aluminum oxide and clay mineral. The mineralogical studies revealed the presence of goethite, kaolinite, diaspore and rutile respectively.

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